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REMOVABLE CORE FOR PRE-STRETCHED TUBE

Technical Field of the Invention

The present invention relates to a core for supporting an elastomeric tube in a radially expanded or pre-stretched condition wherein the core can be removed to allow the pre-stretched elastomeric tube (PST) to contract into contact with an object to be enclosed within the tube. Moreover, the present invention relates to a covering assembly comprising a PST and a core for supporting the PST in a radially expanded condition.

Background of the Invention

One method of insulating and environmentally protecting a connector for a power cable or other cable is by use of a contractible insulating tube expanded to fit over the outer surface of a hollow cylindrical core. The tube and the core are slid over one cable end and the cables are connected by means of the connector. Thereafter the tube and the core are repositioned over the connector area and the hollow cylindrical core is removed so that the expanded insulating tube may contract into contact with the connector and the cables.

United States Patent Nos. 3,515,798 and 4,503,105 both describe a one-piece rigid plastic core having interconnected adjacent coils of a core ribbon in a closed helical configuration. One end of the core ribbon is partially unwound and fed back through the core. Pulling on this end will cause the core ribbon to unwind and, accordingly, allow the pre-stretched tube to contract. Because the core ribbon is helically wound, the core ribbon as it is extracted through the space between the core and the object over which the core has been positioned must be rotated around the object as the core ribbon end is pulled. This is cumbersome and does not permit the use of automation to remove the core as the machine cannot release the core on one lateral side of the object and regrasp it on the other lateral side of the object.

PCT Patent Application WO-A-93/22816 and United States Patent No. 5,589,667 both describe a straight pull-out core ribbon which overcomes the aforesaid drawback. The hollow structure of this type of core is formed by bending a flat sheet of plastic material into a tube-like shape. The flat sheet is held in the tube-like condition by means of interlocking means formed at the longitudinal edges of the sheet. The interlocking means elements at the one longitudinal edge interlock with their respective interlocking means counterparts at the other longitudinal edge. The flat sheet is provided with a plurality of parallel weakening lines alternatively starting at the one longitudinal edge of the sheet and terminating at a termination point spaced apart from the respective opposite longitudinal edge. By this configuration, a strip or ribbon is defined which begins at the free end and continues in a serpentine manner between and at the termination points around consecutive lines. Accordingly, the ribbon can be removed by pulling at its free end wherein the direction in which the ribbon or strip upon removal extends around the object over which the core and the PST is repositioned is inverted after each winding. This results in a straight pull-out without twisting successively which simplifies the removal handling. However, the flat sheet of material must be provided with a specific design at its longitudinal edges in order to provide for the interlocking means. This complicates manufacturing of the sheet material. Moreover, forces acting at the interlocking means tend to cause the bent sheet material to go back into its original flat condition; thus, it is somewhat difficult and cumbersome to maintain the tube-like shape of the core while loading the PST. Finally, at the interlocking means the core and the PST deviate from the circumferential design visually which may affect consumer acceptance of the covering assembly formed of the core and PST.

PCT Patent Application WO-A-96/21963 relates to a pre-stretched modular barrier boot having a resiliently deformable T-shaped end closure cap provided with two radially expanded pro-stretched tube portions maintained in the shape by means of a support core as set forth and described in PCT Patent Application WO-A-93/22816 or United States Patent No. 5,589,667 (see Figure 2 and lines 21 to 27 of page 7 of WO-A-96/21963).

European Patent Application EP-A 0 637 117 illustrates another support core for a PST in which a flexible flat sheet having several serpentine like strips is bent to provide a tubular supporting core wherein the lateral edges of the flexible sheet are held together by means of interlocking devices. The problems and disadvantages of this core design are identical to those described hereinabove.

Accordingly, there is a need for a removable core for supporting a pre-stretched elastomeric tube in a radially expanded condition wherein the manufacturing process of the removable core is relatively easy and wherein the removal of the core is achieved by pulling a strip or ribbon thereof straight out without twisting around the object to be enclosed within the PST. There is also a need for a covering assembly for enclosing an object comprising a cold shrinkable elastomeric covering tube and a removable core for supporting the covering tube in a pre-stretched radially expanded condition.

SUMMARY OF THE INVENTION

According to the present invention there is provided a removable core built from a unitary tube made of, by way of example only, a plastic material wherein the unitary tube is provided with primary and secondary weakening lines formed into the unitary tube. The unitary tube with its weakening lines forms the removable core which consists of at least one strip or ribbon extending circumferentially about the tube in a serpentine manner.

The unitary tube of the removable core according to the invention is provided with a primary line of localized weakening extending from a first end of the tube to a second end thereof opposite to the first end. Transversely to the primary weakening line there are several secondary lines of localized weakening which preferably extend substantially circumferentially about the tube. Each of these secondary weakening lines starts from the primary weakening line and extends to the one side of the primary weakening line up to a termination point at the other side of the primary weakening line and spaced apart therefrom. That means that each secondary weakening line extends about less than 360° and nearly about one winding. The secondary weakening lines are substantially parallel to

each other. Accordingly, this secondary weakening line design provides for a strip or ribbon extending substantially circumferentially about the tube in a serpentine manner from the first end of the tube to its opposite second end. The strip is fed back from one of the ends of the tube through the tube so as to project from the other end of the tube.

One of the main aspects of the present invention is that the integrity of the unitary tube forming the removable core is maintained from the beginning of the manufacturing process of the removable core until its removal from the PST supported by the core. No interlocking means are necessary for maintaining the tubular shape of the removable core. The strip or ribbon of the removable core according to the invention can be pulled straight out without twisting around the object to be covered by the PST over more than one winding since those portions of the serpentine-like strip between a termination point and the primary weakening line defining a point of unwinding direction inversion point at which the direction in which the strip is unwound when pulling it is inverted by 180°.

Basically, the primary line of localized weakening can be a straight line being parallel to or inclined with respect to the longitudinal axis of the unitary tube. However, due to stability reasons it is preferred that the primary weakening line be somewhat wave-shaped like, for example, corrugated, triangular, rectangular or trapezoidal. The wave-shaped design of the primary weakening line is preferably symmetrical to a (phantom) line to the opposite lateral sides thereof the primary weakening line extends. This symmetry line can be a straight line or a curved line, that is, a line inclined with respect to the longitudinal dimension of the tube.

According to the above-mentioned preferred embodiment of the invention, the primary weakening line extends in a zig-zag-like manner within a strip-like area of the tube wherein this strip-like area has a defined width. The distance between a termination point of a secondary weakening line and the primary weakening line can be smaller than, equal to or larger than the width of the strip-like area.

It is also preferred to provide the unitary tube at the termination points of the secondary weakening lines with radially extending holes in order to facilitate bending of the strip when pulling out the same.

One can think about several designs for weakening the unitary tube along its primary and secondary weakening lines. Preferred methods are to provide perforations or a reduced thickness into the wall of the tube. Both the perforations and the reduced thickness can be provided in an extruded tube in which the primary and secondary weakening lines are formed by ablation of material of the tube using, for example, a laser, an electron beam or plasma to locally heat the tube so as to remove material from the tube. As an alternative, the tube can be cut mechanically using a knife or a similar cutting tool, or hydraulically using a fluid jet, such as a water jet with or without additional abrasive material in the fluid. In yet another alternative, the unitary tube can be injection molded wherein the mold is provided with the necessary structures for forming perforations or grooves or both in the wall of the tube.

From all of the methods mentioned above for forming the weakening lines in the tube, laser ablation is most preferred. It is known that certain polymers are decomposable by powerful laser energy. One example of such a polymer is poly-oximethylene (POM). Moreover, it is known that other polymers, although by themselves being not laser-ablatable, can be provided with this feature by incorporating suitable fillers like silica. By way of example only, polyolefins such as polyethylene and polypropylene, copolymers, polyamide, polyvinylcloride, starch modified biodegradable polymers can all be used as materials for the core. Suitable fillers for increasing IR absorption of the laser or other energy beam include carbon black, graphite and other suitable dyes. Many other materials which are laser-ablatable or ablatable by other kinds of energy beams are known and, accordingly, can be used in the invention.

The ablation process can be done from either the outside or the inside of the tube by deflecting the energy beam using devices like mirrors or the like or by direct application of the beam energy be means of an optical fiber. Depending on the desired characteristics

of the core, the ablation can be non-penetrating, creating a continuous line of reduced thickness or can be locally penetrating so as to create a perforation-like structure or a combination of these measures. Another way to achieve the desired weakening lines is to combine a layer of non-ablatable polymer with a layer of ablatable polymer by, for example, co-extruding POM with a clear cellulose-acetate.

As indicated above, the removable core of the invention preferably can be formed from inexpensive extruded tubes as preforms to make the removable core for the PST with the advantage of creating a straight pull-out PST core. From a manufacturing standpoint, there is virtually no limit to the pattern of the weakening lines since in the prior art there are lasers and other cutting equipment which are CNC-controlled having a good repeatability and automation of the manufacturing process.

One additional advantage of the removable core of the invention is that due to the integrity of the unitary tube there are no portions of the tube extending out of the circumferential contour of the tube. This results in a design of the PST and core assembly which is acceptable to both the industry and the persons using the assembly.

According to another aspect of the invention there is provided a removable core, wherein each of the at least two weakening lines extends alternately to opposite lateral sides of a respective phantom line. In this embodiment, the core comprises at least two strips extending in a serpentine manner along around one half of the periphery of the unitary tube. Accordingly, when pulling at each of the strips the core can be removed from inside of the PST wherein the unwinding direction of each of the strips is inverted at each of the two primary weakening lines between which the strip extends.

In a further aspect of the invention, there is provided a removable core for supporting a pre-stretched elastomeric tube in a radially expanded condition comprising a unitary tube having first and second opposite ends, a plurality of sections of a primary line of localized weakening spaced apart and arranged adjacent to each other wherein the arrangement of the plurality of primary weakening line sections extends from the first end

of the tube to the second end thereof and a plurality of substantially parallel secondary lines of localized weakening, a group of secondary weakening lines being associated to each of the primary weakening line sections, respectively, wherein each secondary weakening line of the group extends from the associated primary weakening line section at the one side thereof to a termination point at the other side of the respective primary weakening line section and spaced apart therefrom, wherein adjacent secondary weakening lines of the group extend from the respective primary weakening line section at different sides thereof to termination points at the respective other side of the respective primary weakening line section, and wherein from one end of a respective primary weakening line section there extends a secondary weakening line at the one side of this primary weakening line section to an opposite end of an adjacent primary weakening line section at the other side thereof to define a strip beginning at the first end of the tube and continuing substantially in a serpentine manner within the areas of the plurality of primary weakening line sections and continuing substantially helically between respective adjacent primary weakening line sections to the second end of the tube the strip comprising a free end starting from the second end of the tube and extending through the tube so as to project from the first end of the tube.

According to this embodiment, the unitary tube of the core of the invention has individual sections of a primary weakening line with the arrangement of these sections extending from the first end of the tube to its second end. The primary weakening line sections are arranged adjacent and spaced apart from each other wherein each section comprises two opposite ends and wherein two adjacent sections have their contracting ends spaced apart. The design of tube and the extension of the primary and secondary weakening lines within the area of each of the sections of the primary weakening line is as described above. In addition thereto, in this embodiment of the invention, there are secondary weakening lines starting at the one end of a primary weakening line section, continuing in a circumferential direction, and terminating at the confronting end of an adjacent primary weakening line section. By this arrangement of weakening lines the strip defined in the circumferential wall of the tube extends substantially in a serpentine manner

within the areas of each of the primary weakening line sections while the strip extends substantially helically between adjacent primary weakening line sections.

When pulling at the strip, within the areas of each of the primary weakening line sections the unwinding direction of the strip is inverted by 180° after each winding and is inverted by 180° after at least two windings in the areas between two adjacent primary weakening line sections with the unwinding directions of the strip within the areas between each group of three successive primary weakening line sections are inverted with respect to each other. Accordingly, although the strip does not change its unwinding direction for more than one winding within the areas between successive primary weakening line sections, no twisting of the strip around the object to be covered by the PST occurs.

The primary weakening line sections can be straight or curved with the confronting ends of each pair of sections being displaced and in alignment circumferentially or in a substantial circumferential direction. The term curved in this connection means that the primary weakening line section not necessarily is bent smoothly but can also be in a zig-zag shape, triangular or "u"- or "w"-shape. Between adjacent sections the secondary weakening line connecting the confronting edges of the two primary weakening line sections may extend for one or more windings so that the strip in this area extends substantially helically for several windings.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more thoroughly described with respect to the accompanying drawings in which like reference numerals refer to like parts in the several views and embodiments, and wherein:

Figure 1 is a partially broken away side view of a PST supported by a removable core according to one embodiment of the invention wherein the removable core and the PST are positioned over a cable connector.

Figure 2 is a perspective view of one embodiment of the removable core according to the present invention.

Figures 3-6 are side views of removable cores according to several embodiments of the invention differing with respect to the shape of the primary weakening line and the distances between the termination points and the secondary weakening lines to the primary weakening line.

Figure 7 is a perspective view of another embodiment of the removable core according to the present invention.

Figures 8 and 9 are side views of additional embodiments of the removable core according to the present invention.

DETAILED DESCRIPTION

A first embodiment of a removable plastic core **10** supporting a cold shrinkable elastomeric tube **12** is shown in Figure 1. The elastomeric tube **12** is partially cut away in order to illustrate the design of weakening lines formed in the hollow core **10**. The covering assembly **14** comprising the removable core **10** and the pre-stretched and radially expanded elastic covering tube **12** is positioned over a cable connector (not shown for clarity of illustration) connecting two electrical cables **16** each comprising a conductor **18** and an insulating covering **20**.

By removal of the hollow core **10** the radially expanded covering tube **12** contracts so as to sealingly contact the connector and the cables **16** circumferentially. If necessary, an insulating mastic or tape can be arranged between the insulating coverings **20** of the cables **16** and the elastic covering tube **12**.

The cold shrinkable elastic covering tube **12** may be made from an elastic tube which may be expanded to a larger diameter and subsequently allowed to shrink back to substantially its original dimensions when the hollow supporting core **10** is removed.

In most applications, the precise chemical nature of the material used to form elastic covering tube **12** is not of particular importance except that it must possess sufficiently high elasticity which allows it to be stretched and then to shrink to substantially its original dimensions. Rubbery elastomers such as natural rubber, natural and synthetic polyisoprenes, cis-polybutadiene and styrene butadiene rubber, butadiene-acrylonitrile rubber, polychloroprene, (neoprene), butyl rubber, polysulphide rubber, silicone rubber, including liquid silicone rubber, urethane rubber, polyacrylate rubber, epichlorhydrin homo- and copolymer rubbers, propylene oxide rubber, fluorosilicone rubber, fluorocarbon rubber, chloro-sulphonated polyethylene rubber, chlorinated polyethylene rubber, ethylene-propylene rubber, ethylene-propylene-diene monomer terpolymer rubber (EPDM), nitroso rubber, phosphonitrilic rubber, or polyurethanes, including two component polyurethanes, polyurethane elastomers and polyurethane thermoplastic elastomers (TPE) may be suitable. Preferred materials include ethylene-propylene-diene monomer terpolymers (EPDM) and silicone rubbers. Any of the above materials may be formulated in a variety of compositions by including flame retardants, conductive materials, materials to improve weathering properties, materials to produce electrical stress grading properties, glass or carbon fibers, inert fillers and so forth. In particular, the elastic covering tube **12** may be insulating, conductive or electrically stress grading as required for telecommunication, medium or high voltage applications.

The hollow plastic supporting core **10** is shown in Figure 1 in a side view and in Figure 2 in an isometric view. Accordingly, the core **10** is comprised of a tube **22** having a first end **24** and an opposite second end **26** defining the longitudinal dimension of the core **10**. Moreover, in the wall of the tube **22** there is formed a primary weakening line **28** extending from the first end **24** of the tube **22** to its second end **26**. The primary weakening line **28** is corrugated, extends over a width **30** in circumferential direction of the tube **22**, and is symmetrical to a phantom line **29**.

Transversely to the primary weakening line **28** there extends a plurality of parallel secondary weakening lines **32** in circumferential direction of the tube **22**. Each secondary weakening line **32** at **34** starts from the primary weakening line **28** and extends at the one

side thereof circumferentially to a termination point **36** located at the opposite other side of the weakening line. The termination points **36** are spaced from the locations **34** on the primary weakening line **28** where the secondary weakening lines **32** start, by a distance **38** in the circumferential direction. In this embodiment the distance **38** is smaller than the width **30**.

When viewing at the core **10** from its lateral side, the primary weakening line **28** can be regarded as a wave form function. The locations **34** at which the secondary weakening lines **32** start are alternately located at the hills and valleys of the corrugated primary weakening line **28** wherein the termination points **36** are located between two adjacent hills or two adjacent valleys, respectively. By this design, the wall of the tube **22** can be regarded as being built by a strip or ribbon **40** extending in a serpentine manner circumferentially of the tube **22** wherein adjacent portions **42** of the strip **40** are separated by a secondary weakening line **32**. Each portion **42** of the strip **40** extends around 360° of the tube **22** wherein adjacent portions **42** are connected by connecting portions **44** limited by a portion of the primary weakening line **28** and extending around a termination point **36**. At the second end **26** of the tube **22**, the strip **40** continues so as to form a free end **46** extending from the second end **26** of the tube **22** through the tube **22** so as to project from the first end **24** of the tube **22** forming a portion **48** which can be grasped manually or by means of a suitable tool (tongs or the like).

Along the primary **28** and secondary **32** weakening lines the wall of the tube **22** is weakened. These weakening lines are built by means of perforations extending through the wall of the tube **22** with web portions of the tube wall between adjacent portions or by means of grooves formed in the outer side or inner side of the tube **22**. The perforations or grooves most preferably are built by ablating material out of the wall of the tube **22**. This can be performed by means of a laser beam using a laser ablatable plastic material like POM for the tube **22**. The termination points **36** are preferably provided as radially extending holes **50** also formed in the tube by laser ablation.

Referring back to Figure 1, for removing the core **10** out of the pre-stretched covering tube **12** one has to pull at the grasping portion **48** away from the first end **24** of the core **10** resulting in an unwinding of portions **42** of the strip **40** which unwinding starts at the second end **26** of the core **10** towards its first end **24**. When unwinding, the strip **40** does not wind for more than 360° around the cables **16** since after 360° unwinding in the one direction the moving direction of the strip **40** is inverted for 360° and so on. Therefore, the strip **40** can be pulled straight out.

Figures 3 to 6 show individual embodiments of different supporting cores **52**, **54**, **56** and **58** according to individual embodiments of the invention. In these Figures like reference numerals are used for those parts which are similar or identical to the individual parts of the core **10** according to Figures 1 and 2.

As in Figures 1 and 3, the primary weakening line **28** of the core **52** of Figure 3 is corrugated. However, the distance **38**, by which the termination points **36** of the secondary weakening lines **32** are spaced apart from the locations **34** where the secondary weakening lines **32** start, is substantially identical to the width **30**.

According to Figure 4, the overall extension of the primary weakening line **28** is inclined with respect to the longitudinal dimension of the core **54**. Accordingly, the primary weakening line **28** although itself corrugated extends helically with respect to the longitudinal dimension of the core **54**.

Figures 5 and 6 each shows cores **56** and **58** respectively having a triangular or trapezoidal primary weakening line **28**.

Finally, in Figure 7 a perspective view of another embodiment of a core **60** according to the invention is shown. Also in this Figure those parts of the core **60** which are similar to corresponding parts of the cores according to the other embodiments, are specified by like reference numerals.

The specific feature of the core **60** of Figure 7 is that its tube **22** is comprised of two strips **40** each extending over 180° in a serpentine manner and terminating at separated grasping ends **48**. For this purpose the tube **22** of the core **60** is provided with two primary weakening lines **28** displaced relative to each other by 180°. Both primary weakening lines **28** are corrugated wherein between these two primary weakening lines **28** there extend the secondary weakening lines **32** circumferentially from a point **34** at the one primary weakening line **28** to a termination point **36** spaced apart in circumferential direction by a distance **38** from the other one of the primary weakening lines **28**. Accordingly, each of the two strips **40** is comprised of adjacent circumferentially extending portions **42** and portions **44** connecting adjacent portions **42** of the strip **40** wherein each portion **42** extends over around 180° in circumferential direction of the tube **22** so that each of the strips **40** continues in a serpentine manner over 180° along the longitudinal direction of the tube **22**. By pulling at the grasping ends **48** of both of the strips **40** the core **60** is removable out of a pre-stretched elastomeric tube (not shown in Figure 7) supported by the core **60**.

As an alternative, the two strips **40** at the second end **26** of the tube **22** of the core **10** can be connected so that only one free end extends through the tube **22** and projects over the first end **24** of the tube so that by pulling at one end both strips **40** are unwound from the core **60**. Furthermore it is possible that the two free ends **46** of the strips are connected along their lengths so that pulling at these connected ends results in unwinding of both strips **40**.

In Figures 8 and 9 two additional embodiments of a removable core for a PST are shown with like reference numerals indicating like parts as in the other Figures. All the features and characteristics of the core according to the other embodiments described so far apply correspondingly to the embodiments of Figures 8 and 9.

In contrast to the other embodiments, in Figures 8 and 9, the primary weakening line is separated into successively arranged adjacent sections **28** having opposite ends **62**, **64** wherein the confronting ends **62**, **64** of adjacent sections **28** are displaced in

circumferential direction. Adjacent sections **28** are oriented opposite to each other and are curved or zig-zag-shaped. Within the areas of the sections **28** the extension and arrangement of the secondary weakening lines **32** are identical to the other embodiments of Figures 1 to 7. However, the confronting ends **62**, **64** of adjacent sections **28** of the primary weakening line are connected by a secondary weakening line **66**. Accordingly, the strip **40** exclusively comprises sections **68** each extending for two windings. In Figure 9 there are two sections **42** for each primary weakening line section **42** of the strip. Moreover, in Figure 8 the primary weakening line sections **28** are curved smoothly, extend along a half circle, and arranged alternately at opposite sides of the phantom line **29** so as to be displaced in circumferential direction while in Figure 9 the primary weakening line sections **28** are zig-zag shaped like the character "w" and interleaved so that each section **28** extends both sides of the phantom line **29**.

As will be apparent to those skilled in the art, in the light of the foregoing disclosure, many alterations and modifications are possible in the practice of this invention without departing from the spirit or scope thereof. Accordingly, the scope of the invention is to be construed in accordance with the substance defined by the following claims.